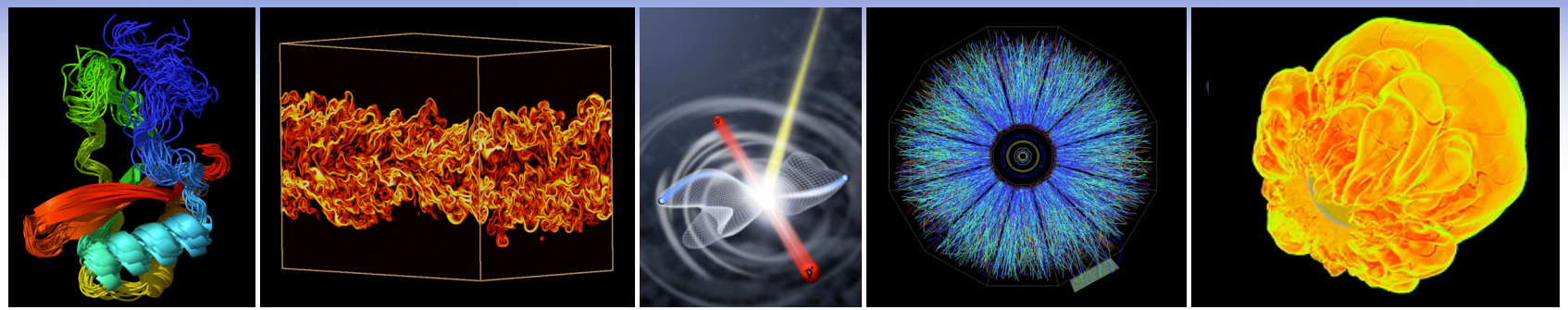

Lustre Performance From the User Perspective

HDF5 Workshop

Katie Antypas

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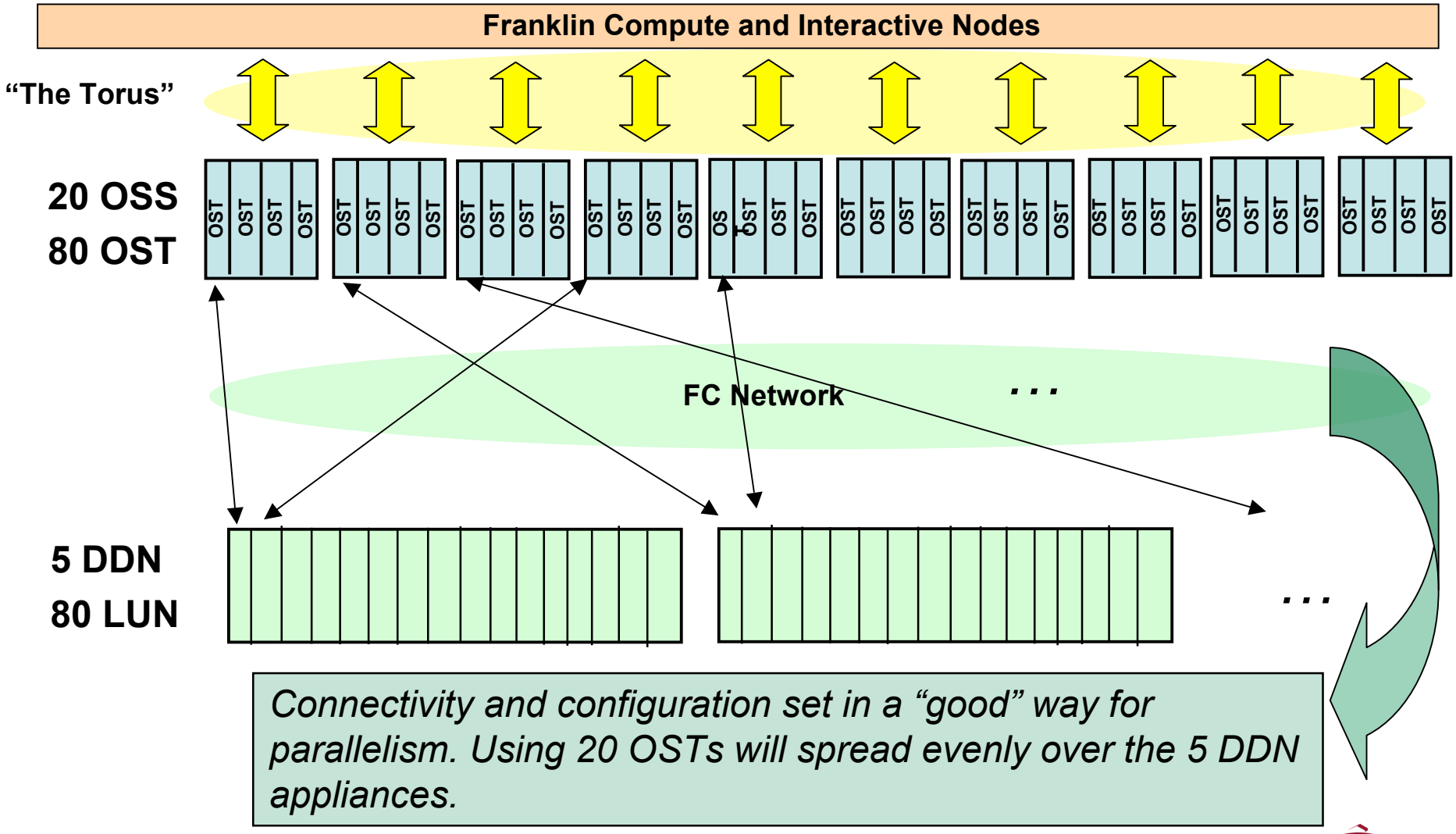
User I/O Wish List

- Single shared file for parallel I/O
- Higher level portable file format
- Consistent I/O performance over a broad range of patterns (within reason)
- Shared file performance matches (or is close to) one file-per-proc performance
- No worries about file striping

Franklin Configuration

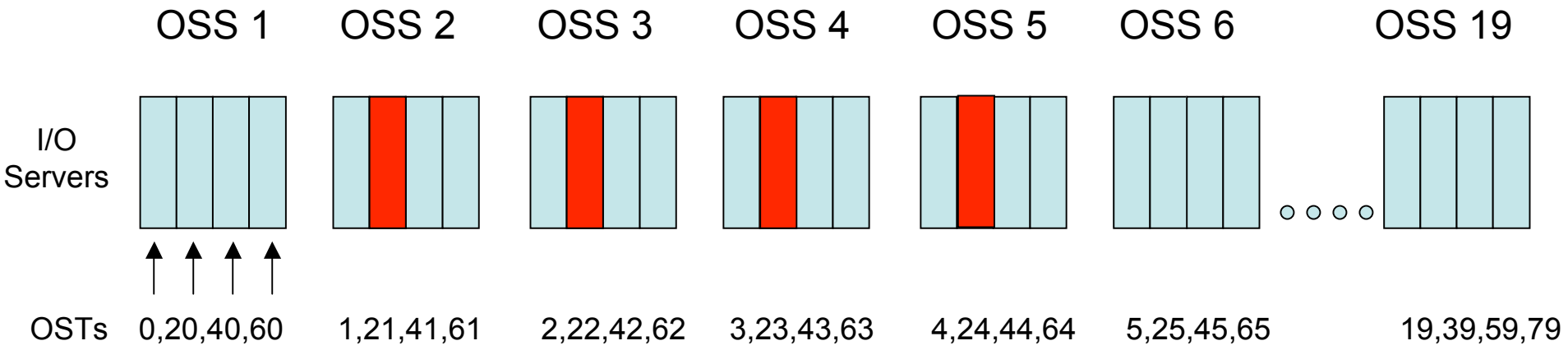


Connectivity and configuration set in a "good" way for parallelism. Using 20 OSTs will spread evenly over the 5 DDN appliances.

File Striping on Lustre

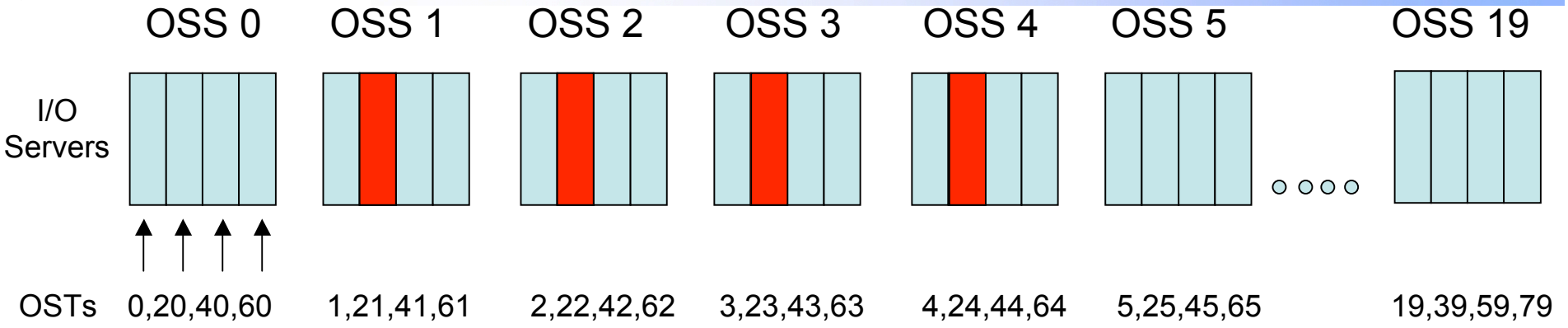
- Lustre file system on Franklin made up of an underlying set of parallel I/O servers
  - OSSs (Object Storage Servers) - nodes dedicated to I/O connected to high speed torus interconect
  - OSTs (Object Storage Targets) software abstraction of physical disk (1 OST maps to 1 LUN)
- File is said to be striped when read and write operations access multiple OSTs concurrently
- Striping can increase I/O performance since writing or reading from multiple OSTs simultaneously increases the available I/O bandwidth

Default Stripe Count of 4 on /scratch



- **Advantages**
  - Get 4 times the bandwidth you could from using 1 OST
  - Max bandwidth to 1 OST ~ 350 MB/Sec
  - Using 4 OSTs ~1,400 MB/Sec
  - In practice using all OSTs 11-12 GB/Sec

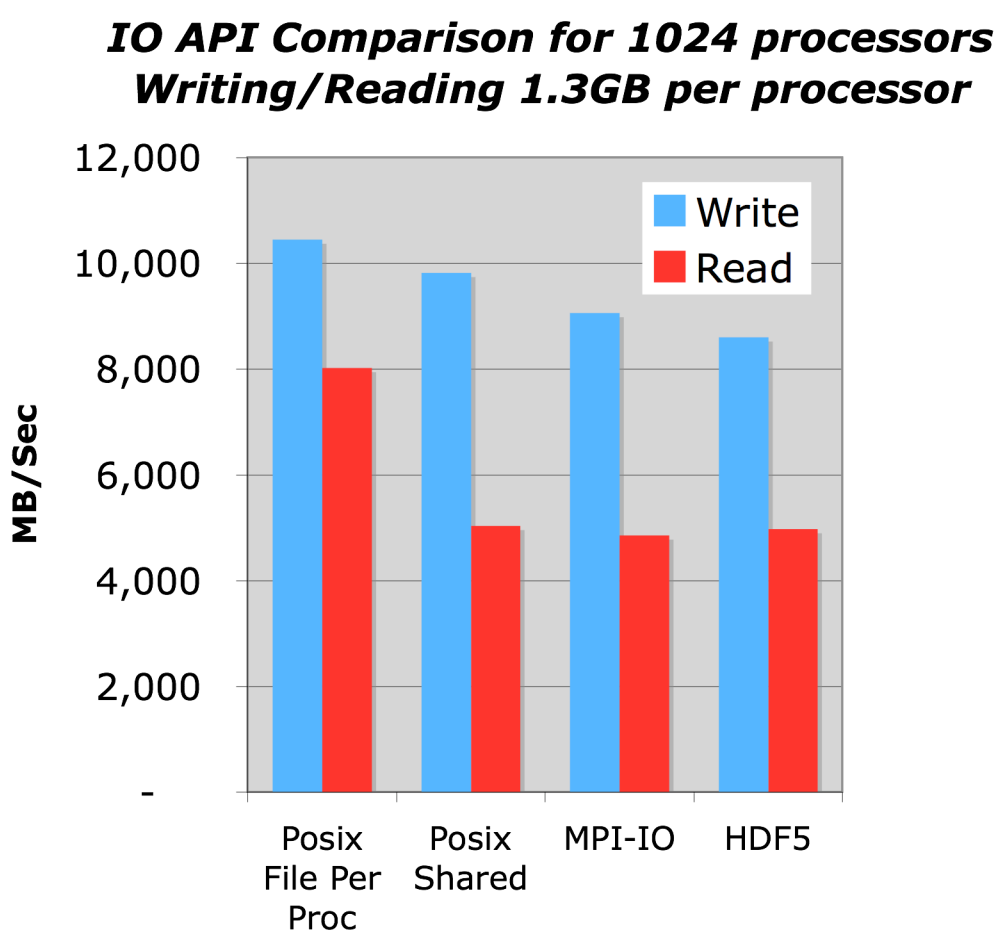
Default Striping on /scratch



- **2 other parameters which characterize striping pattern of a file**
  - **Stripe size**
    - **Number of bytes to write on each OST before cycling to next OST**
    - **Default is 1MB**
  - **OST offset**
    - **Indicates starting OST**
    - **Default is round robin across all requests on system**

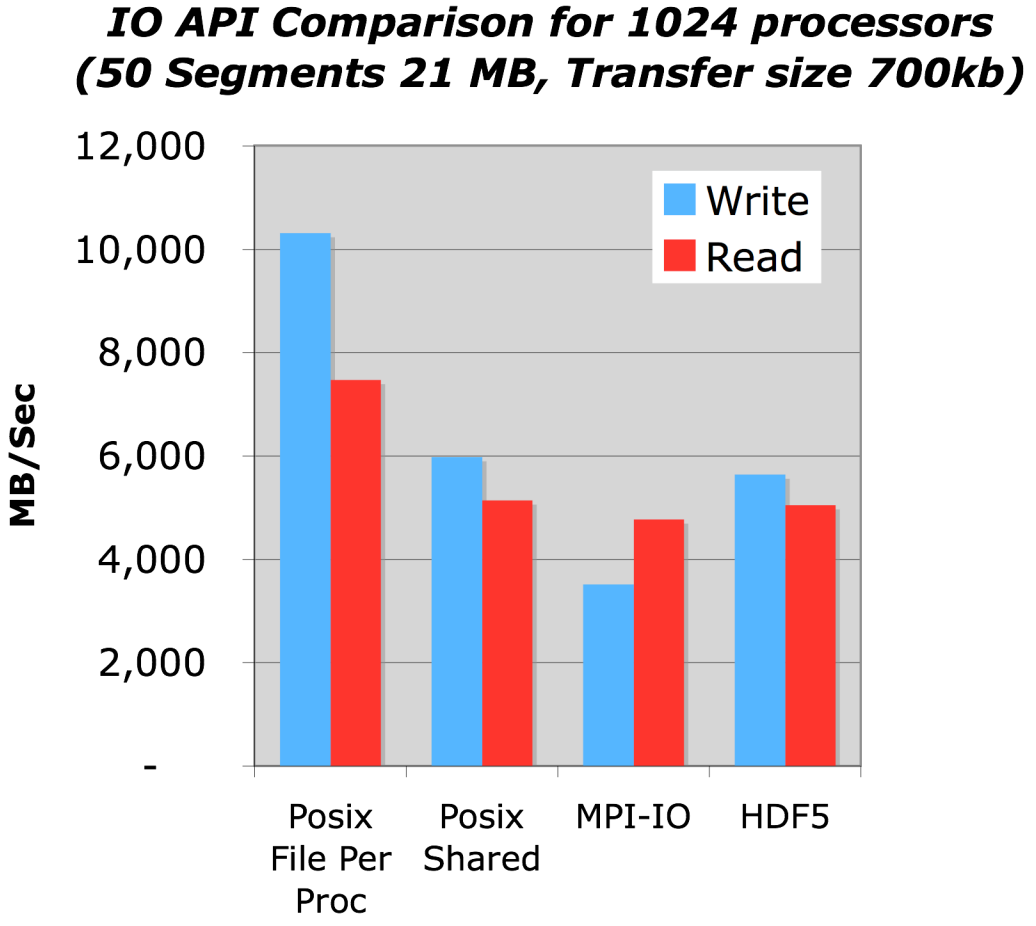
Good I/O Performance with Simple I/O Patterns

- File system capable of high performance for shared files
- Large block sequential I/O
- Transfer size multiple of stripe size
- No metadata



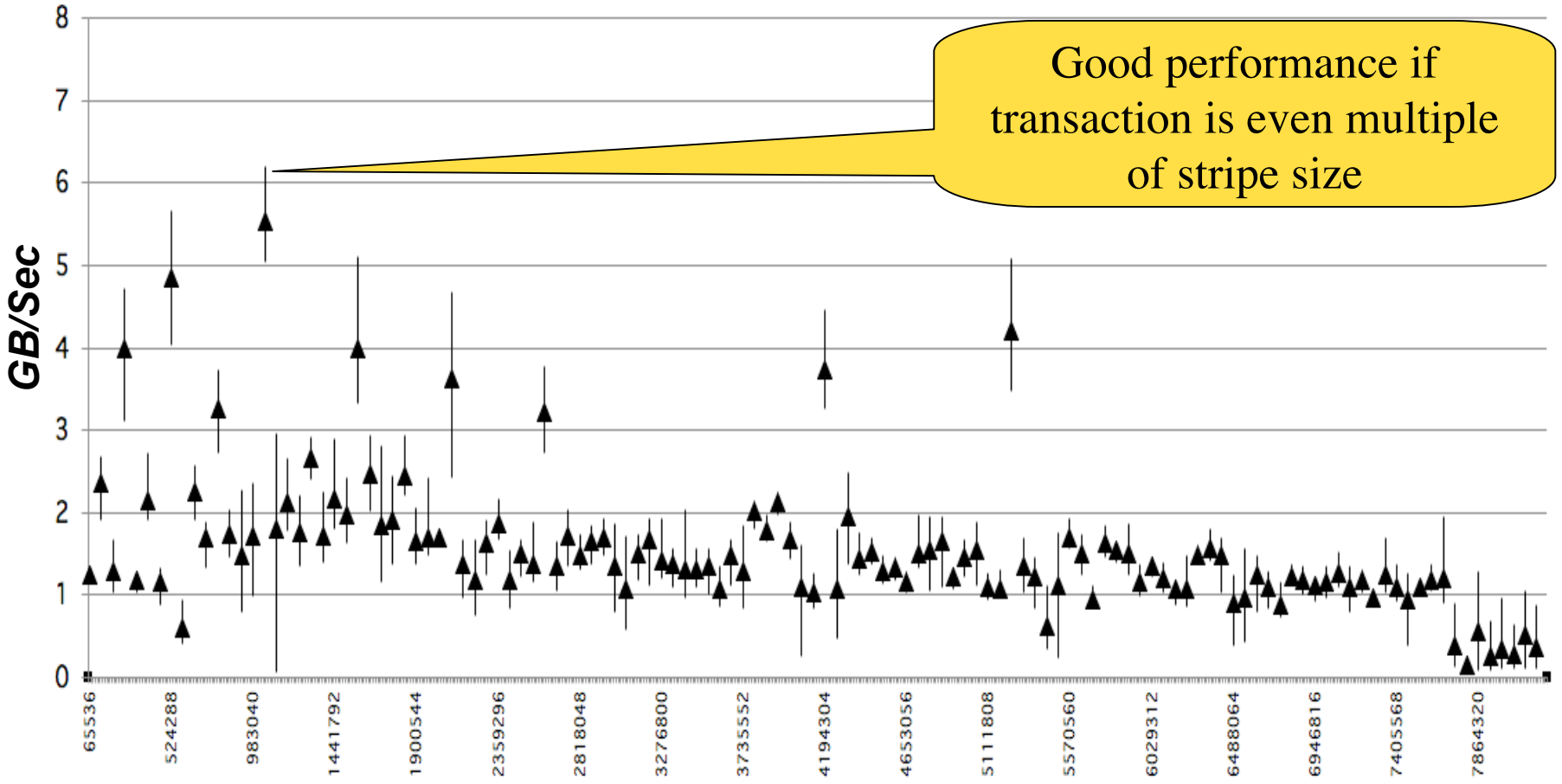
Decreased I/O Performance without Simple I/O Pattern

- Deviations from simple I/O patterns result in performance loss
  - Smaller amounts of data, (MBs/proc)
  - Transfer size not multiple of stripe width
  - Start offset doesn't match stripe width
  - Strided data



I/O Performance Sensitivity to Transfer Size

2GB File Size, 80 Processors, 40 OSTs



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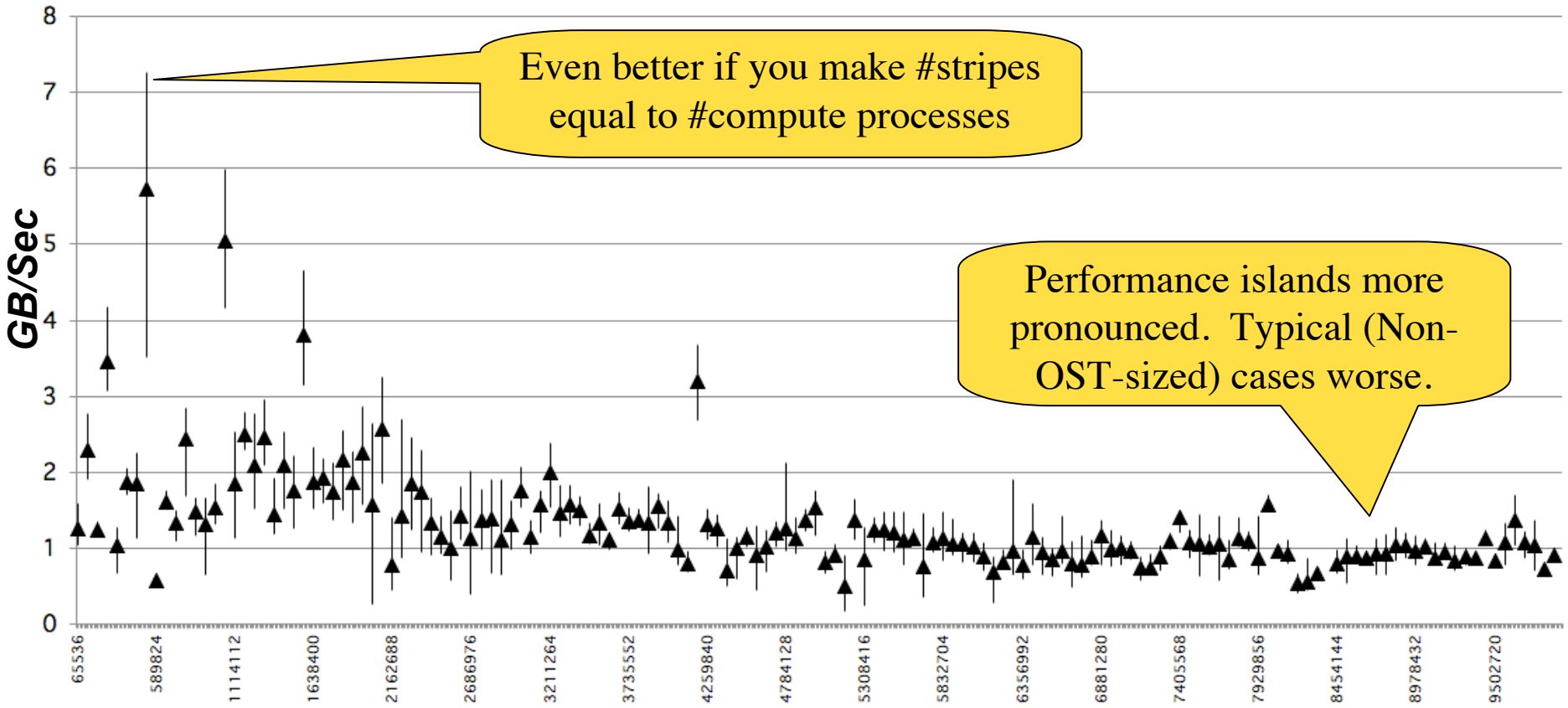
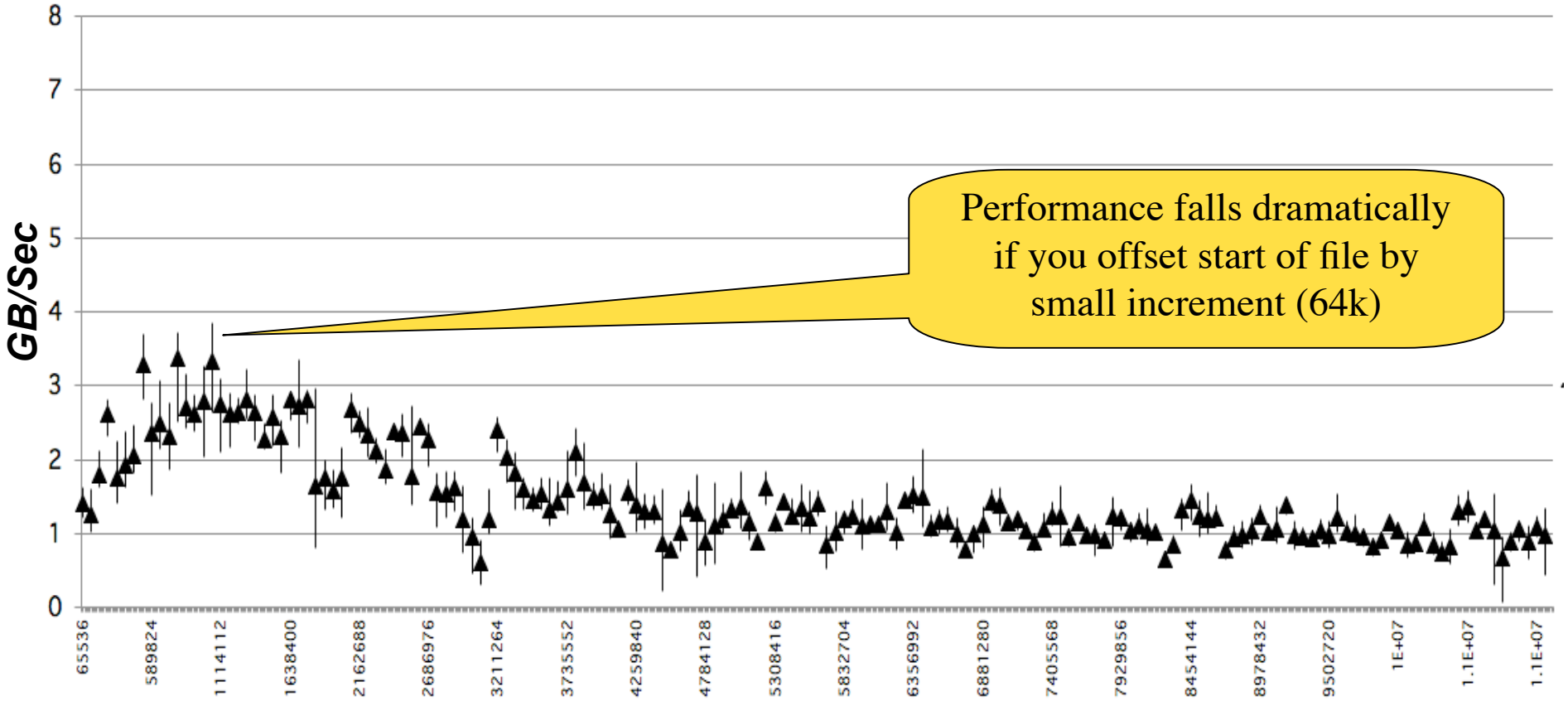
Sensitivity to Transfer Size with OST alignment



I/O Performance Sensitivity to Transfer Size

2GB File Size, 80 Processors 40 OSTs: Offset file start by 64k



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User Perspective: Impractical to aim for such small "performance islands"

- **Reasonable to help users adjust strategies at C/Fortran MPI, MPI-IO, HDF5 layer, but can't require users to understand low level file system details**
- **Transfer size for interleaved I/O must always match OST stripe width**
  - Difficult to constrain domain-decomposition to granularity of I/O
  - Not practical for codes which don't have identical domain sizes
- **Every compute node must write exactly aligned to OST boundary**
  - Not feasible if users write metadata or headers to files
  - Difficult for high-level self-describing file formats (HDF5, pnetcdf)
  - Not practical when domain-sizes are slightly non-uniform

Importance of MPI-IO Optimization for 2 Phase I/O

- We know:
  - Matching number of application I/O writers with number of OSTs gives best performance
  - Writing fewer, larger blocks of data gives better performance than many small writes
  - Writes aligning to OST boundaries get file per proc performance (impractical for apps)
- MPI-IO's 2 Phase I/O precisely addresses above concerns
  - Subset of nodes, called aggregators, do actual writing
  - Aggregators collect smaller chunks of data into larger blocks
  - More aggressive version addresses OST alignment

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Priorities

- Improve MPI-IO implementation on Lustre
  - Investigate poor collective I/O performance
  - Support efforts of David Knaak to implement efficient 2 phase I/O including
    - Aligning data to block boundaries
    - Optimizations to match processors to OSTs
- HDF5 to take advantage of Lustre architecture and optimizations